FABRICATION AND CHARACTERIZATION OF PVA-PVP BASED OCULAR FILM

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE

OF

MASTER OF TECHNOLOGY

IN

BIOMEDICAL ENGINEERING

by

IQBAL HUSSAIN (213BM1004)

Under the guidance of

Prof. MUKESH K. GUPTA

Department of Biotechnology and Medical Engineering

National Institute of Technology, Rourkela

ODISHA

Department of Biotechnology and Medical Engineering

National Institute of Technology, Rourkela

Odisha

CERTIFICATE

Date: May 25/5/15

This is to certify that the work in the thesis entitled "**FABRICATION AND CHARACTERIZATION OF PVA-PVP BASED OCULAR FILM** "submitted by **Mr. Iqbal Hussain (213BM1004)**, in partial fulfilment of their requirements for the award of M. Tech (Biomedical) at the **National Institute of Technology Rourkela**, is an authentic work performed by him under my supervision andguidance. To the best of my knowledge, the matter embodied in the thesis has not been submitted to anyUniversity/Institute for the award of any Degree or Diploma.

Date: 25th May 2015

Prof.MukeshK. Gupta

Associate Professor

Department of Biotechnology and Medical Engineering

National Institute of Technology, Rourkela

DEDICATED TO MY

MOTHER

Department of Biotechnology and Medical Engineering

National Institute of Technology, Rourkela

Odisha

ACKNOWLEDGEMENT

Thanks God the Most Gracious and Most Merciful. It is an honour to place and record profound feeling of appreciation and indebtness to all that have contributed and generously help me in completion of this work. First and foremost. I would like to express my sincere and hearty gratitude to my supervisor **Prof. M. K. GUPTA, Biotechnology and Medical Engineering Department** for all his valuable guidance, critics, support and comments to complete this research work. I am very much grateful to my **ALMA MATTER, N.I.T. ROURKELA** for supporting me financially and give me the opportunity and platform throughout my academic studies. A special thanks to all my mentors for assisting me to complete this work. A deep appreciation and thanks to my fellow colleagues **Gaurav Kulkarni, Shristi Gupta, Gokul Nathan Suraj Nayak, Rohan Bhagwat,Amit Singh, Prashant ,Krishna Mohan, Vineet pandey,Aashish Moharana,** for supporting, and kind assistance throughout the period of study. Word is boundless to express my thanks to my family members for their constant support and prayers which sustained during the hard time and throughout my study. I thank those who have contributed and behind the screens for the successful completion of this work. I would also like to thanks **Tanushree Patra, Praveen Guttula, Vinay singh, Satish Sai, ,Bhisham singh, Senthil guru** for their help and guidance. I would like to express my profound gratitude to my parents and towards all the people who have contributed their precious time and effort to help me in completing this project, without whom it would be impossible to understand and analyse the project.

Submitted by

Iqbal Hussain (213BM1004)

Master of Technology

Department of Biotechnology and Medical Engineering

National Institute of Technology, Rourkela

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

PVA	**Polyvinyl Alcohol**
PVP	**Polyvinyl pyrolydinone**
GE	**Gelatin**
GA	**Glutar Aldehyde**
EDTA	**Ethylenediamine tetra acetic acid**
FTIR	**Fourier transform infrared spectroscopy**
XRD	**X-ray powder diffraction**

ABSTRACT

The eye is standout amongst the most sensitive and complex organs in body,which makes vision possible. Cataract surgery is one of the most common surgeries performed. So after cat aract ocular lens is needed for correcting eye power. In this work wehave used PVA--PVPblends to develop ocular film. Films were cross-linked by freeze thawing process and solvent evaporation. We have prepared films of five different concentrations named S1-S5. As per FTIR S3 S4 have better FTIR peaks. They have refractive index between ranges of 1.75-1.9. They have shown good complex modulus reading during rheological study which was comparable with human crystalline lens. Folding endurance has how flexibility increases with PVP. XRD was performed to check crystallinity, SEM and Mechanical testing was performed to measure strength and Youngs modulus. We have also performed haemocompatibility degradation study and got favorable result. Finally we can conclude that it may be used as contact lens purpose

CHAPTER 1

INTRODUCTION

INTRODUCTION

The eye is a standout amongst the most sensitive and complex organs in the body, which makes vision conceivable. Accordingly, manufactured materials that are to be utilized as a part of the eye need to have extremely extraordinary properties. A cataract is portrayed as (nearby) haziness of the lens and loss of vision of the patient because of biochemical changes in proteins of the lens. Optical restoration of vision after cataract surgery can be acquired by implantation of an intraocular (IOL) as a distinct option for a cataract display, which is overwhelming and limits the field of perspective of the patient.

Among the numerous basic strides in the continuous quest for perfect IOL improvement lens material and configuration are profoundly imperative. Poly(methyl methacrylate) (PMMA) is the major and the most critical homo-polymer in the arrangement of acrylics with adequate high glass transition temperature(Tg) has been the material of decision for IOL Contact lenses mostly are bio compatible with the ocular surface, as in they are not toxic and are by and large very much endured by the visual tissue. The improvement of materials that are endeavouring to copy particular parts of the ocular surface be that the water substance of the cornea or an organizing of the tear film or the lipid layer of the tear film is energizing. Cataract surgery is one of most common surgery performed. After that for replacing opacified space intraocular lens is needed. The final goal of cataract surgery is to improve power of eye. Both currently used material PMMA and silicone made lens are very stiff, creates accommodation problem. From previous decades attempts have been made to select a suitable material for IOL. Previous studies have shown that crystalline lens use to possess viscoelastic properties. In this study we have used Poly-vinyl alcohol (PVA) and Poly (N vinyl 2-Pyrrolidinone) PVP blend has been used. PVA is a commonly used biomaterial for

ocular drug delivery because of its biocompatibility, electrochemically stable, non-toxic, high film forming property, transparency, and its property to physically crosslink. On the other hand PVP is a vinyl polymer which has polar side groups due to presence of peptide bonds in the lactum ring. It is widely used for biomedical purpose because of its conductivity water solubility properties. In this we have used the property of PVA to crosslink physically with different polymers and we have used cross linkers like Glutaraldehyde and Potassium hydroxide and sodium sulphate. And for physical cross-linking repetitive freezing and followed by thawing process. Different samples of different concentration were made. Different characterization were done like cross linking, XRD, Mechanical testing, Contact angle measurement were performed and result were analysed

CHAPTER 2

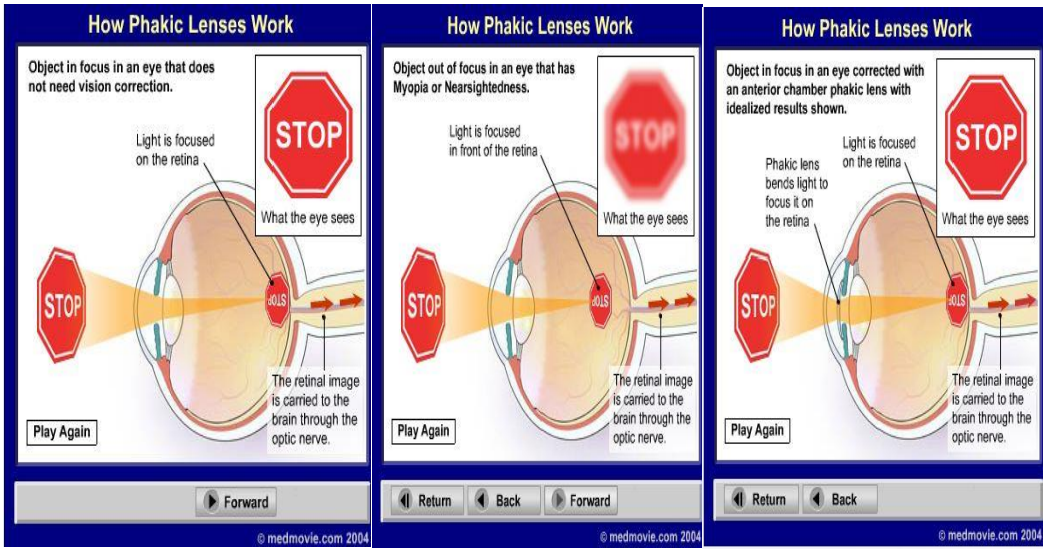
LITERATURE REVIEW

LITERATURE REVIEW

Historical beginning of biomaterials for IOL

Harold Ridley from London was the initially noted individual to have utilized PMMA as ocular insert from coverings of British Royal Air power planes (Refojo 1975). His choice of material was based on coincidental implantation of covering in pilot's eye which were seen by him as tolerable without creating any irritation or any inadmissible natural outcomes. The PMMA straightforwardness was likewise one component for choice. His IOL was too enormous and cumbersome weighing around 110mg in air. It was hard to mechanically fit them.

Phakic intraocular lenses, or phakic lenses, will be lenses made of plastic or silicone that are embedded into the eye forever to lessen a man's requirement for glasses or contact lenses. Phakic alludes to the way that the lens is embedded into the eye without evacuating the eye's characteristic lens. Amid phakic lens implantation surgery, a little cut is made in the front of the eye. The phakic lens is embedded through the entry point and put just before or simply behind the iris.(U.S. FOOD AND DRUG ADMINISTRATION).



.Fig 1 Phatic lens working

Biomaterials : A natural or manufactured substance which can be brought into body tissue as a major aspect of an embedded implant or used to supplant an organ, bodily function, and so forth. All biomaterial should possess some basic properties to be called as biomaterials like biocompatibility, nontoxic, etc.(Park and Bronzino 2002) They can be classified in four different groups Metals, polymers, ceramics and composites(Hench 1998). Metals are mainly used for hard tissue replacements, polymers are prefer for soft tissue implants.

Metals: Vanadium steel was the first metal used for biomedical purpose. It was used for fractured bone plates and for screws(Geetha, Singh et al. 2009). Because of their high strength they are used for orthopaedic implants.(Picha and Thompson 2014)

Ceramics: A ceramic can be any metal, metalloid, non-metallic, or organic substance bonded together with ionic or covalent bond(Sáenz, Rivera et al. 1999). They can be further classified in three types resorbable , nonabsorbable and biodegradable or non-inert. Examples zirconia and carbons are classified inert, dense hydroxyapatites are bioreactive and materials like calcium phosphate can be classified as resorbable ceramics.(Geetha, Singh et al. 2009)

Polymers: Polymers are large chains of monomers. They are flexible and less strength so they are basically used for soft tissue implants. They can be used for Blood and solution bag, surgical packaging , dialysis devices, catheter bottles, connectors, catheter, pouch, flexible container, and orthopaedic implants Polypropylene Disposable syringes, blood oxygenator membrane, suture, artificial vascular grafts ,Blood pump ,membrane for blood dialyzer, implantable ocular lens, and artificial vascular grafts, and heart (Paradossi, Cavalieri et al. 2003).

Composite Biomaterials: As the word composite say they are materials made from two or more different biomaterial of different property form a third material having a property different from both. Examples can be bio glass ceramics, acrylic ceramics etc(Jones and Rizkalla 1996).Composites can be used in bone cement, bone replacement,dentle implants , bone cage, tendon, ligament replacement(Ramakrishna, Mayer et al. 2001)

Polymer blends: The polymer we have used here are PVA, PVP and Gelatin.. They are used because of their non-toxicity, biocompatibility, film forming property and water solubility property.

PVA: It is prepared using vinyl acetate as monomer. It has hydroxyl group which is attached to its methane carbon. It possess an crystalline and hydrophilic nature(Finch 1973)

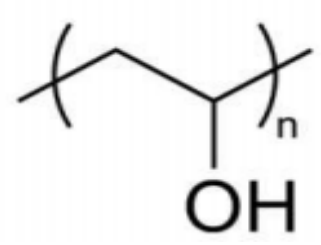


Fig 2 Structure of PVA

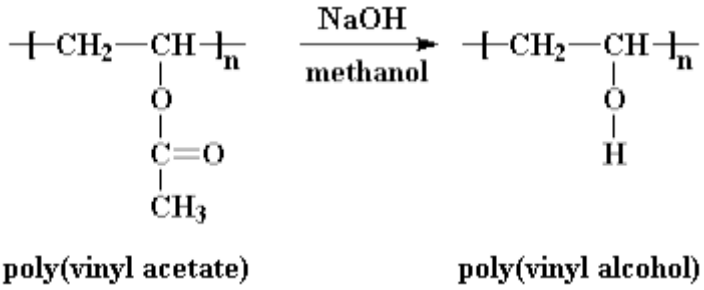


Fig 3 Polymerizaion of PVA from vinyl acetate

PVP : Its monomer is N vinylpyrrollidone. Due to containing peptide bonds in lactum rings it possess highly polar side groups

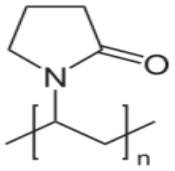


Fig 4 Structure of PVP

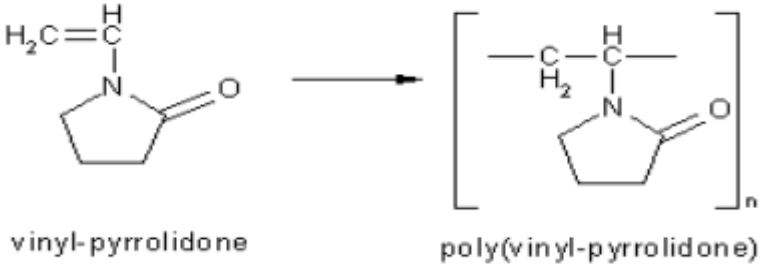


Fig 5 Polymerization of PVP from vinyl pyrrolidone ((BALA))

Gelatin : It a colour less, brittle and flavourless food stuff. Gelatin is a blend of peptides and proteins created by incomplete hydrolysis of collagen extricated from the skin, bones, and connective tissues of creatures. It is used to reduce the strength of our films

Physical crosslinking property of PVA.The most punctual endeavour for crosslinking of PVA utilizing freezing–thawing system has been spearheaded by Semi-crystalline PVA gels were arranged by uncovering PVA solution for redundant freezing–thawing cycles which impelled crystallization and result in a system structure, which go about as physical crosslinking destinations in the system. The freezing–thawing technique is respected the best and the favoured strategy for acquiring physically cross-linked PVA hydrogel without utilizing any conventional toxic compound crosslinking operators (Yokoyama et al).Numerous polymers have been already mixed to PVA to meet such clinical requests or once in a while to add to a polymeric framework suitable for particular biomedical applications, for example, drug delivery purpose(Kobayashi, Chang et al. 2005), tissue engineering or wound dressing(Kenawy, El-Newehy et al. 2010). The mixed polymers with PVA are similar to PVP, (Park and Chang, 2003).The medical uses of PVA are including contact lenses, inserts (Nakamura et al., 2001), artificial used organs (Kobayashi, Chang et al. 2005)and drug delivery (Li et al., 1998). This is a direct result of the qualities of PVA, for example, biodegradability, the characteristic non-harmfulness, non-carcinogenetic, great biocompatibility, and alluring physical properties, for example, rubbery or flexible nature. Application of PVA hydrogel on wound dressing has been reported (Singh and Pal 2011)

Objective of the work:

- To Prepare film using Freeze thawing process
- Prepare films of different concentrations of PVA-PVP
- Characterisation
- Biocompatibility test

CHAPTER 3

MATERIALS AND METHODS

3. MATERIAL AND METHODS

For this study we have used HIMEDIA chemicals, PVA (60-125 KDa)**,** PVP-(30 KDa) **,**PBS buffer (100ml,pH-7.4)- (, NaCl- 0.8g**),** Glutaraldehyde is also used during some samples as a cross linker. Five different samples were prepared for our study with different concentration of PVA and PVP sample

Table 1 Different sample prepared

Sr No.	**Sample**	**Concentration (PVA:PVP:Gelatin)**
1	**S1**	**1:1:0.1**
2	**S2**	**2:1:0.1**
3	**S3**	**3:1:0.1**
4	**S4**	**4:1:0.1**
5	**S5**	**5:1:0.1**

3.1 EXPERIMENTAL PROCEDURE

3.1.1. Preparation of polymer solution

- PVA SOLUTION : 10% of PVA solution is prepared using 4 gm. of PVA was added to 40 ml of distilled water

Heated at 110 deg. atr 350 rpm

till 1 Hrs till homogenous solution is prepared

PVP solution : 10 % PVP solution was prepared using 4 gm of PVP was added to 40 ml of distilled water

Heated at 60° C at 350 rpm for 30 minutes

Till homogenous solution is prepared

Gelatin solution : 10 % gelatin solution was prepared using 4 gm of PVP was added to 40 ml of distilled water

Heated at 60° C at 350 rpm for 30 minutes

Till homogenous solution is prepared

Fig 6 Sample preparation

3.2.2 FILM CASTING

After the solution is prepared, make five different sample. Than they are kept in -20ºc freeze for 16 hrs, than they are kept in room temperature for thawing , this cycle is repeated one more time and then after they are kept in hot air oven at 65 ºc for 16hrs , than we are able to get our films

3.3**CHARACTERISATION**:

Samples were further characterised by following techniques:

3.3.1 FTIR ATR analysis:

This is done to check whether our films are crosslinking or not. Because crosslinking is one of measure feature which tells about film solubility, degradability, and about its different property. If we can find bonds at required points than our polymers have cross-linked properly otherwise not, and so the will degrade easily while swelling. As per our ocular films they should not degrade easily. Small circular films were cut and then they are sandwiched in between KBr and then pallets are formed for our ATIR FTIR .

3.3.2 Optical Properties:

Optical density: To check the increase in the transparency with respect to different concentration of PVA PVP and Gelatin. It is done using spectrophotometer. We have used spectrophotometer at 600 nm. All films were made of 2.5 cm length and 0.5 cm width, and of around 0.25 mm thickness.

3.3.2.1 Refractive index of the film:

The refractive index of the films were measured using Abbe refractometer, refractive index was measured using 598 nm wavelength filters .Samples were cut accordingly

3.3.3 FOLDING ENDURANCE VALUE:

This test is used to check the flexibility of the film to stand on different number of folds. In this technique we measures the number of folds after which our films breaks. And then log of that is find. The specimen was folded from the centre by using finger and thumb and then opened this whole thing is termed as single fold

3.3.4 Contact Angle Measurement

Contact angle is basically an angle which is formed in between the interface of a solid mainly our specimen and the liquid mainly water droplet .This test is done to check whether our prepared film is hydrophilic or hydrophobic. For this films are cut in 1×1 cm^2 , then it is put on instrument a drop of water is dropped on it , if the angle made by drop's outer layer with film is acute than hydrophilic otherwise hydrophobic

3.3.5 Mechanical properties

In this part the tensile strength of the films were measured using Universal Tensile Machine, Films were cut in length of 2.5 cm and width of 0.5cm .First the thickness of the films were measured using strain gauge. Than film films were placed in UTM slot for specimen. After this machine was started and till our film brakes it runs. So we had measured young's modulus, tensile strength, strain at break. Our tensile strength of ocular film should of moderate modulus; it should not of very high modulus. For this purpose only we have used Gelatin as it is also hydrophilic and it reduces the strength of the film

3.3.6 SWELLING TEST AND SOLUBILITY TEST

Swelling property of a material tell how much water a material can hold. It can be calculated by the formula given below

W =M – M1 / M1

M2 = weight of water soaked film

M1 = weight of dry film (initial)

Films were cut in 1centimeter square dimension and then placed in 5ml of PBS. After every hour the change in mass was calculated. Extra PBS can be soaked using tissue paper. Finally samples were kept for drying

Solubility factor can be calculated by diving initial and final swelled film mass with initial mass and multiplying it with 100

M3 is the weight of fully dried film

3.3.7 DEGRADATION TESTS

This test is done to check that in how many days ours film is degrading. For this there are many ways one of the ways is by using PBS. Sample with 1*1 cm are used, it is put in 12 ml of PBS and checked for degradation

3.3.8 THICKNESS OF THE CAST

The thickness of films were measured using screw gauge , and verified using verniercalliper, both are standard way of measuring thickness of films

3.3.9 X-RAY DIFFRACTION

XRD readings were taken for samples by keeping the diffractometer at 45kV and

40Ma.The diffractometer reading were measured for the range of 2ɵ between10-60 at an speed of 10 degree/minute

3.10 **SEM STUDY**

Film morphology, organization and estimations of the fibres were considered utilizing filtering electron intensifying lens with an empowering voltage of 20 kv. Picture were studied using Image programming for the figuring of the ordinary width of the film. A Scanning Electron Microscope (SEM) is a kind of electron amplifying instrument which plans photos of a case by filter it with centre light emission. The electrons from the machine interact with the electrons of sample, using different indictors that are known and in this manner we get information regarding morphology of our sample. For SEM study a very small part of sample was taken, than it was kept for gold sputtering for few minutes, after that it was put on the SEM holder. It was send in the chamber after that we have seen the images and taken

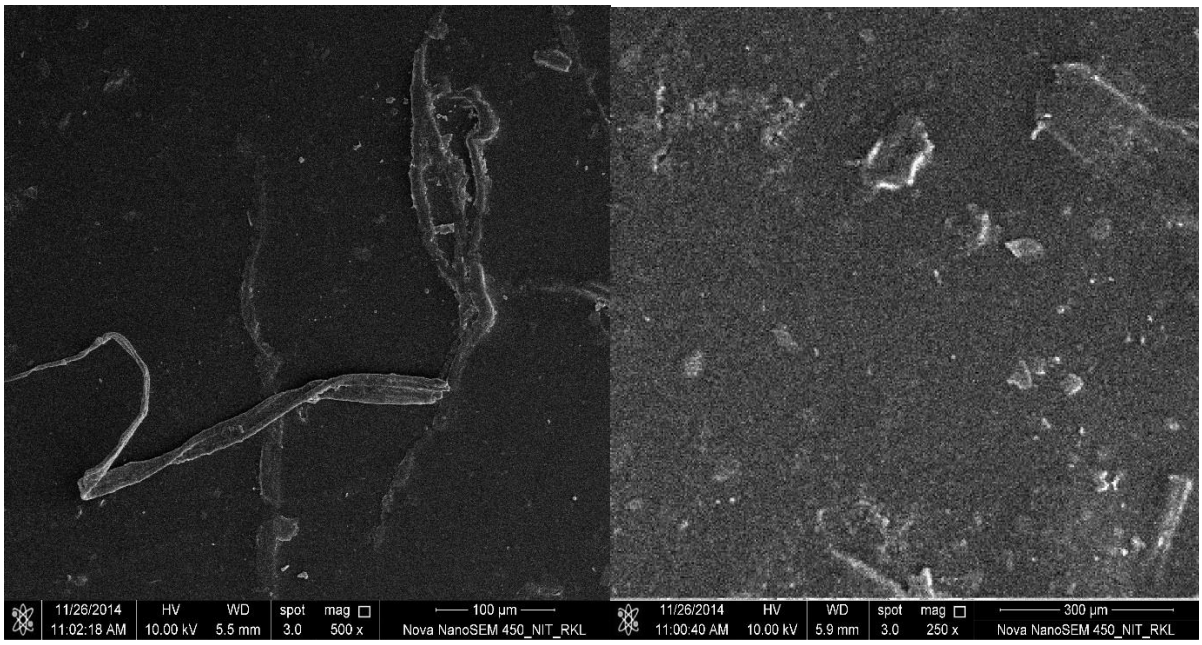


Fig 7 SEM images

3.3.11 Rheological testing

The ocular films were viscoelastic materials. Viscoelastic is the property of material in which a material stresses -strain response is dependent on applied strain rate. A Rheometer was used to check rheological property of ocular film. Our ocular film was first fully hydrated in saline solution. The complex stress and strain were plotted and complex shear was calculated. A normal human lens have complex shear modulus of 50(BALA , Leone, Consumi et al. 2011). So we have calculated for our sample and compared.

3.3.12 HEMOCOMPATIBILITY TEST

It's a test performed to check if our films are compatible with blood or not. Around 10 ml of 0.9% saline was added in 8 ml of blood (Dilution proportion was 10:8). EDTA was used for anticoagulant. At that point in 9ml of saline and 0.5 ml of dilute blood was added, for testing sample 0.5 ml of sample was included the arrangement. 0.5 ml of 0.1 M HCL and 0.5 ml of saline were included rather than test example in the blend of blood and saline (9 ml saline + 0.5 ml dilute blood) to know for positive and negative control. The samples were kept in the incubator with the positive and negative control, and after that centrifuged at 1000 rpm for around 10 minutes. The upper portion free from cells was taken and then OD was determined using spectrophotometer at absorbance 545 nm

Haemolysis was calculated using the formula

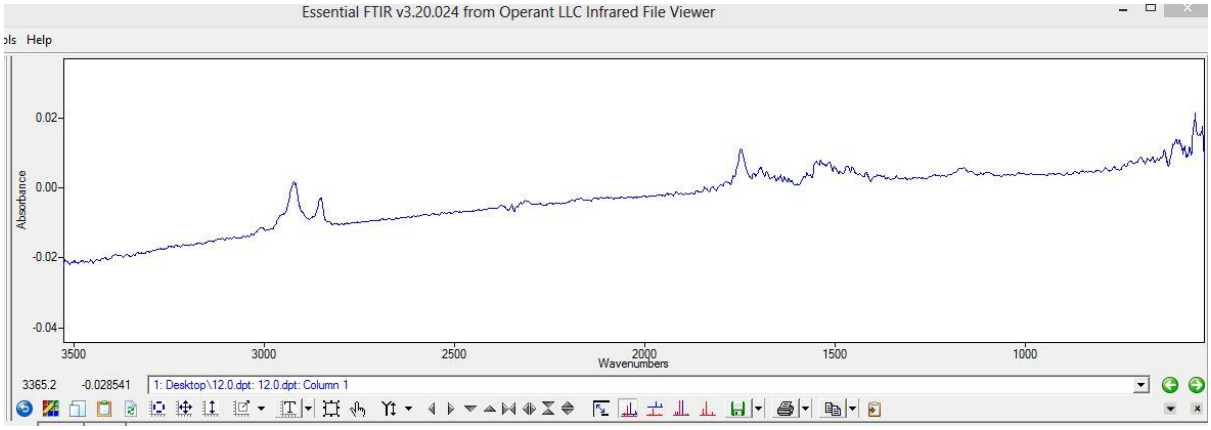
$$\% \text{ Haemolysis} = (O.D._{\text{sample}} - O.D_{\text{—ve control}}) / (O.D._{\text{+ve}} - O.D_{\text{—ve control}}) \times 100$$

CHAPTER 4

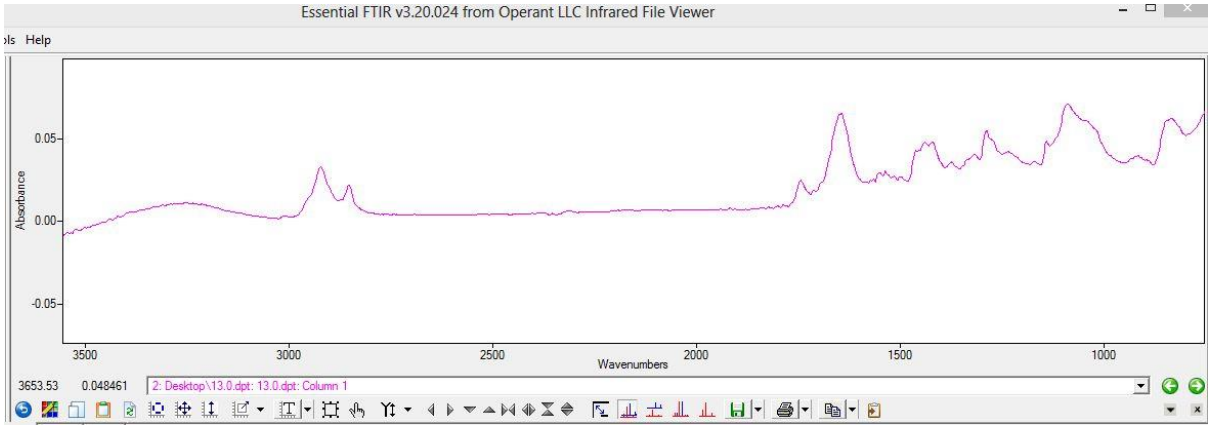
RESULTS AND DISCUSSIONS

4. RESULTS AND DISCUSSIONS

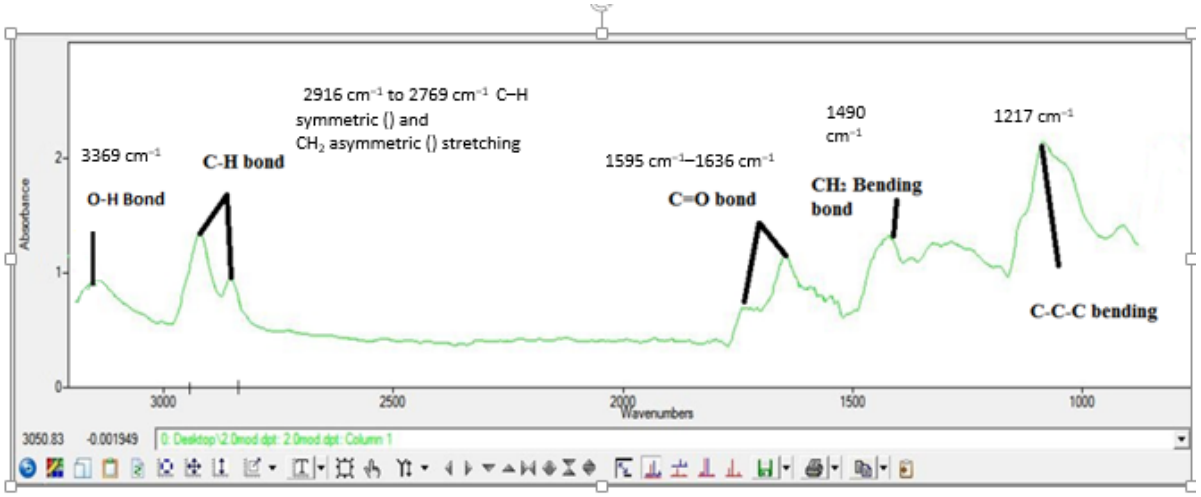
FTIR analysis: Infrared spectra obtained are plotted below, and important wave numbers are shown



a)



b)



c)

Fig 7 (a,b,c) FTIR data

Peaks at 3369 are because of hydroxyl group , peak at 2916cm^{-1} to 2769 cm^{-1} C-H symmetric and CH_2 asymmetric streching bond . Peak at 1595cm^{-1} is of ketone bond. Bond at 1490 cm^{-1} is because of CH_2 Bending and 1217 cm^{-1} is C-C-C bending. Hydrogen bond has been formed between the hydroxyl group of PVA and proton from PVP.(El-Mohdy and Ghanem 2009) -NH out-of plane wagging at 670 cm–1 indicating the formation of an esterifies product (after esterification bond length is shortened, resulting in the shift of the peak to a higher wave number). Since there are no peaks at 1680 cm–1 it can be concluded that all the free carboxylic groups of Gelatin have been esterifies.(Mansur, Oréfice et al. 2004)

4.2 FOLDING ENDURANCE VALUE

Folding endurance test is done to check the elasticity and brittleness of films. The folding endurance of the film was increased by increasing the PVP concentration in the film. This can concluded from their polymeric continuous structure is hard to break. This study shows that by increasing PVP the strength and flexibility has increased(BALA)

Table 2 Folding endurance data

Sample name	1st reading	2nd reading	3rd reading
S5	**197**	**210**	**200**
S4	**241**	**210**	**251**
S3	296	286	277
S2	336	301	390
S1	496	487	515

4.3 DEGRADATION TEST: Film samples were kept in PBS buffer for 20 days

4.3.1 **pH Analysis**- pH change was recorded for films in this days , there was no pH change was observed , so no degradation as pH change is considered one of the criteria for degradation test. As the pH was around 6-7 an only no change so it can be concluded that films are not degrading.

4.4 SWELLING TEST: Swelling weight was got after the films were completely swelled. PVA crystallites plays two different role in membrane one as reduce the absorbed solvent and also restrict membrane swelling by physical cross-linking effect

The addition of PVP reduced the crystallinity of film as by our XRD data, so by doing so swelling power the film was increased. And by loss of crystallinity transparency was affected

4.5. THICKNESS OF THE FILM

Thickness of the films were measured using strain gauge, it is one of precise method to measure thickness. Film thickness is one of the important factor for film, like if more the thick film more it can swell, thickness of film depends on the volume of the solution we take

Table 3 Thickness of the film

Sample	**Thickness(mm)**
S1	0.13
S2	0.15
S3	0.15
S4	0.13
S5	0.13

4.6. Optical properties

Table 4 Optical density of films

Sample Name	**1st reading**	**2nd reading**	**3rd reading**
S1	0.203	0.201	0.105
S2	0.197	0.198	0.208
S3	0.150	0.167	0.171
S4	0.147	0.162	0.152
S5	0.132	0.139	0.147

This shows that the optical density of films were decreasing in the fixed pattern, so as we know optical density is inversely proportional to transparency as our optical density is decreasing so our transparency is increasing, this can be explained as increasing PVA concentration crystallinity is increasing so more crystalline more transparent

Measured Refractive Index of films:

Table 5 R.I. values

Samples	**Refractive index**
S1	1.7602
S2	1.7658
S3	1.7761
S4	1.788
S5	1.7615

4.6 Contact angle result:-

The values of contact angle are below 90 for all the samples, so we can say all are hydrophilic in nature. As we have added gelatine there was a further increase in hydrophilicity as angle has dropped from 80 to approx 40

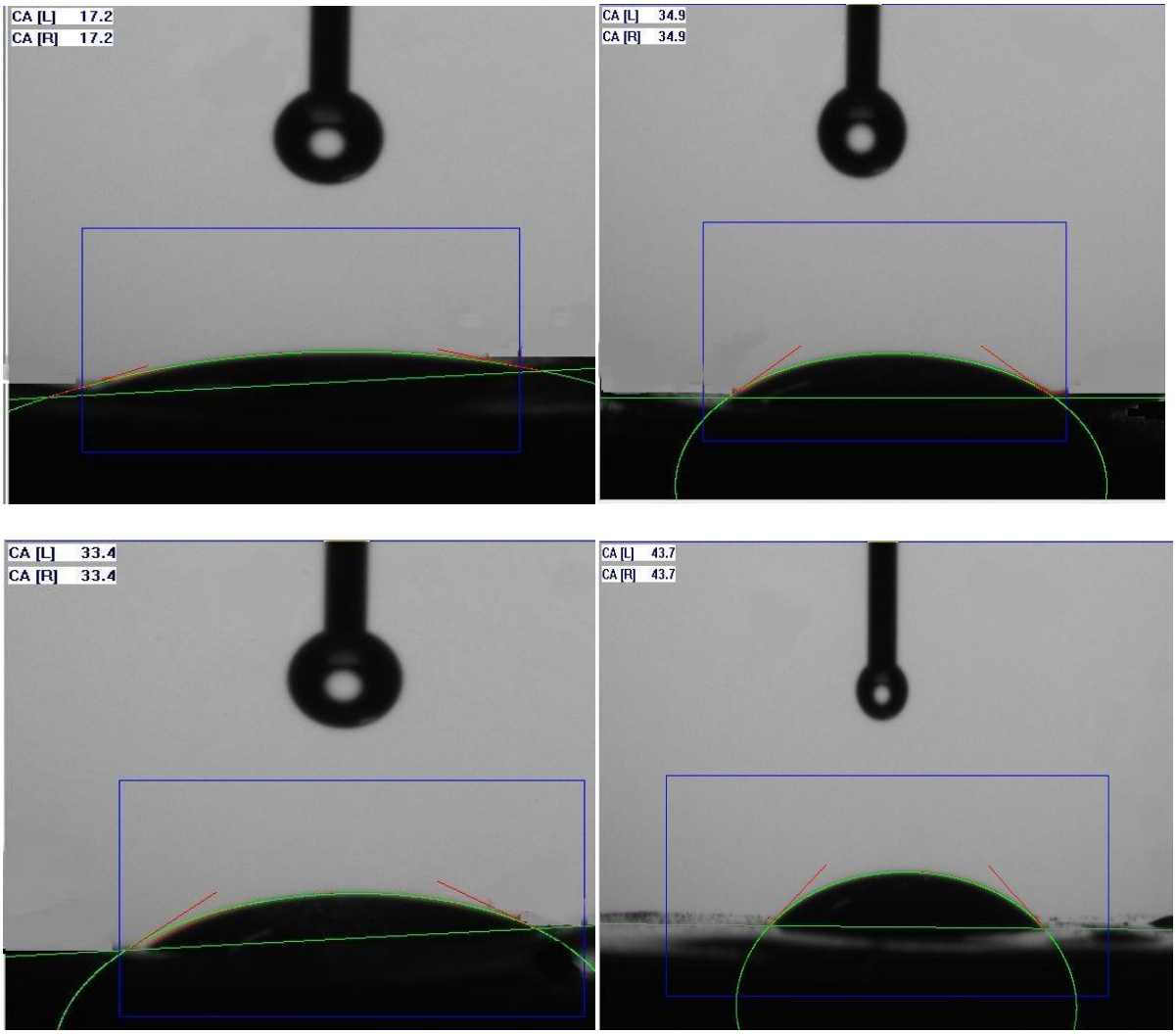


Fig 8 Contact angle images

Table 6 Contact angle readings of film

Sr. no.	**Sample name**	**Contact angle values**
1	S1	43
2	S2	17.2
3	S3	38.9
4	S4	44.3
5	S5	42.1
6	Without Gelatin	84

4.7 Mechanical Analysis:

Rheological Analysis: The IOL is crystalline and viscoelastic in nature. For measuring rheological properties rheometer was used. By reading the data we can find the value of complex shear modulus.

Complex shear modulus after samples fully hydrated (0.9% saline)

Storage modulus VS Strain % graph:-

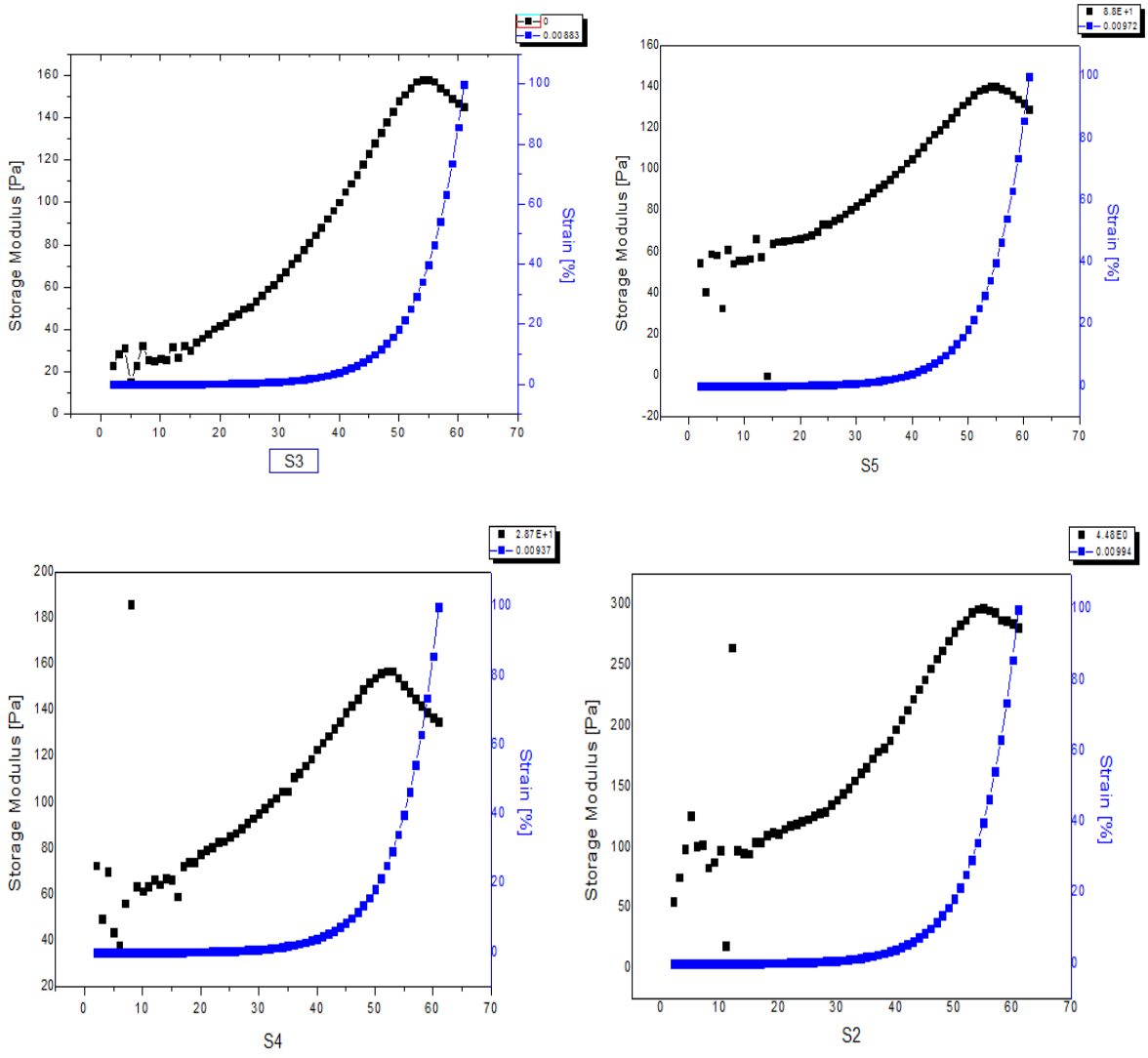


Fig 9 Strain vs storage modulus for the hydrated film

Loss Modulus vs Strain %

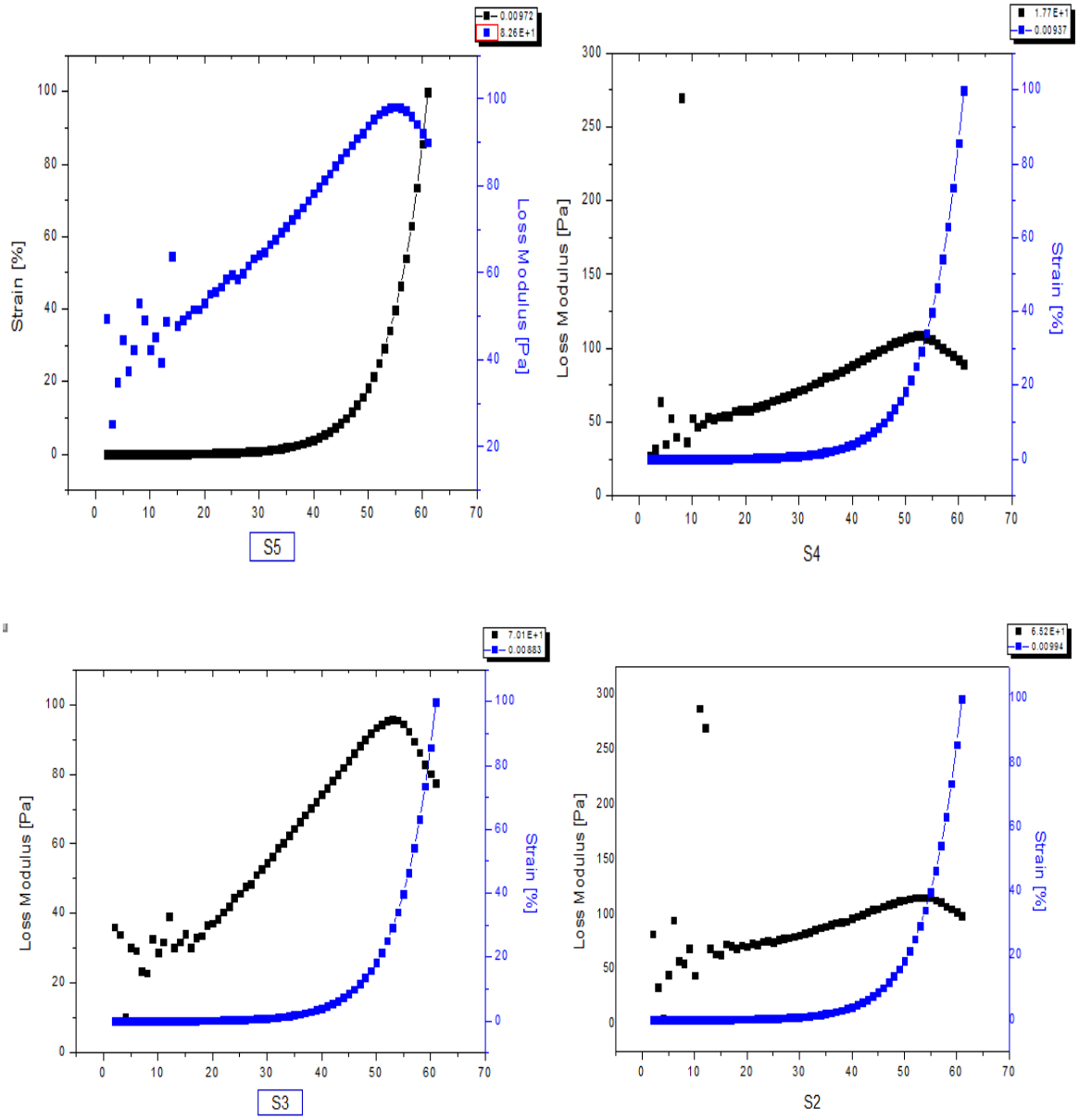
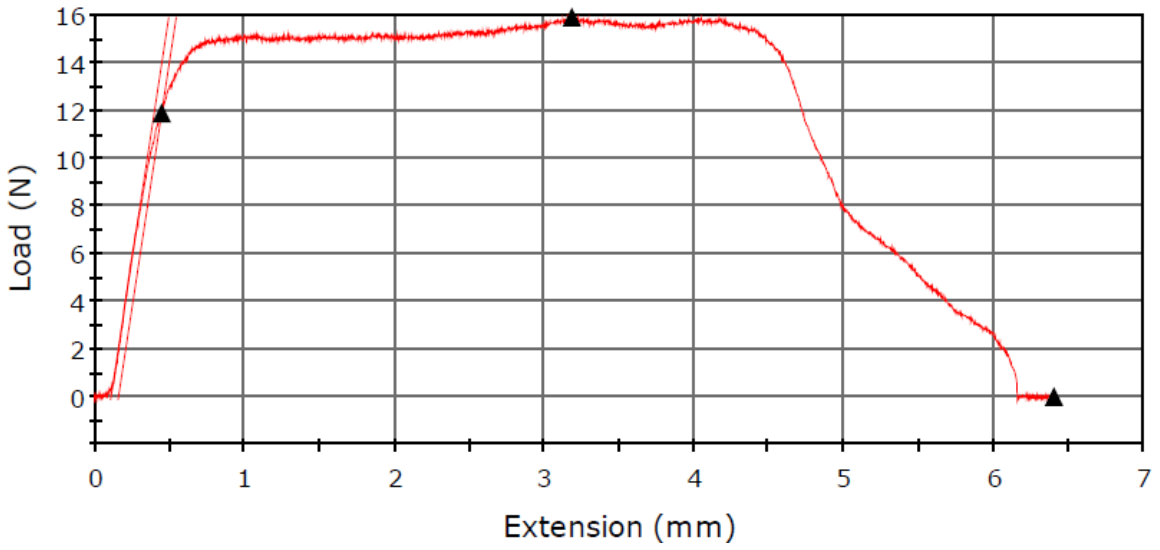
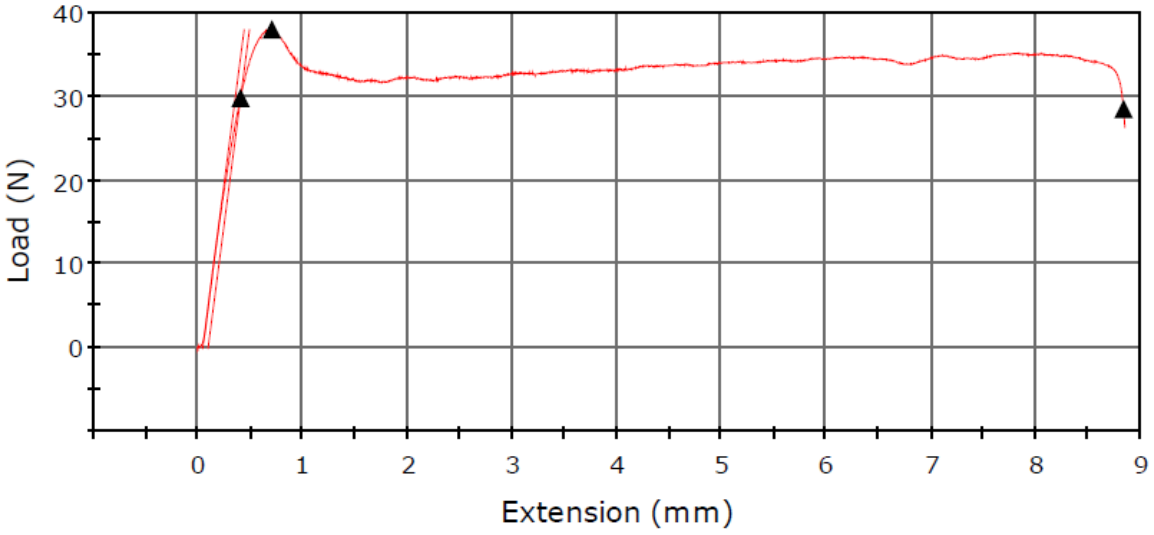


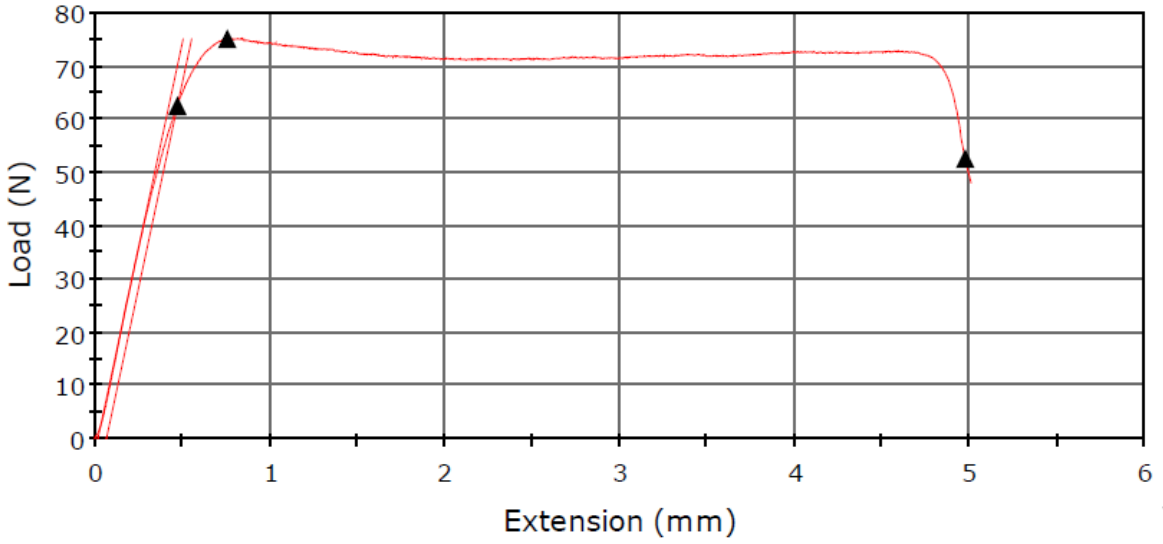
Fig 10 strain % vs Load modulus data

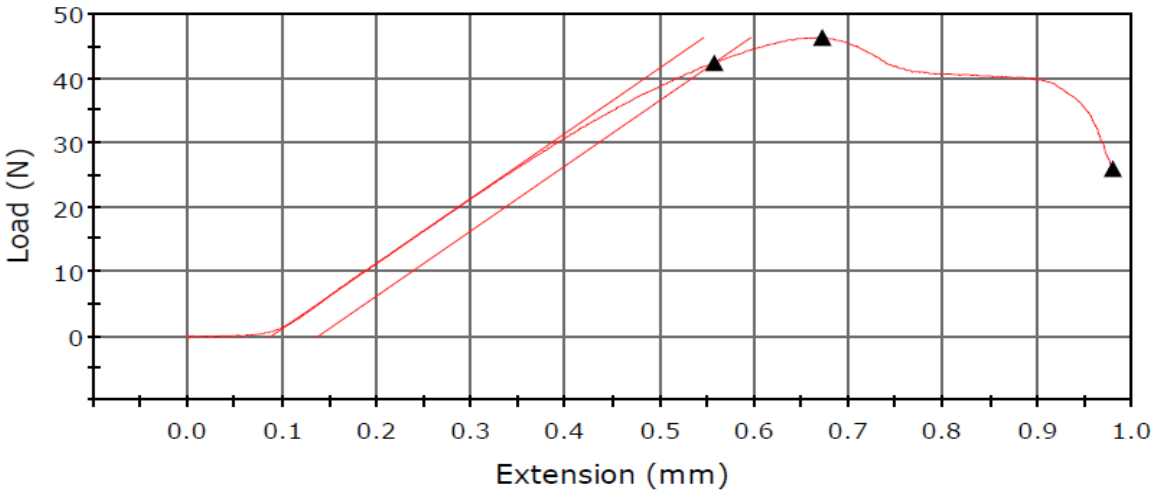
The complex modulus of PVA PVP geatin based film to be in between 40 to 100 so it is comparable to that of normal human lens values(Leone, Consumi et al. 2011).

Mechanical strength of dry films


Load (N)
Extension (mm)
0
1
2
3
4
5
6
7
0
2
4
6
8
10
12
14
16


Load (N)
Extension (mm)
0
1
2
3
4
5
6
7
8
9
0
10
20
30
40


Load (N)
Extension (mm)
0
1
2
3
4
5
6
0
10
20
30
40
50
60
70
80



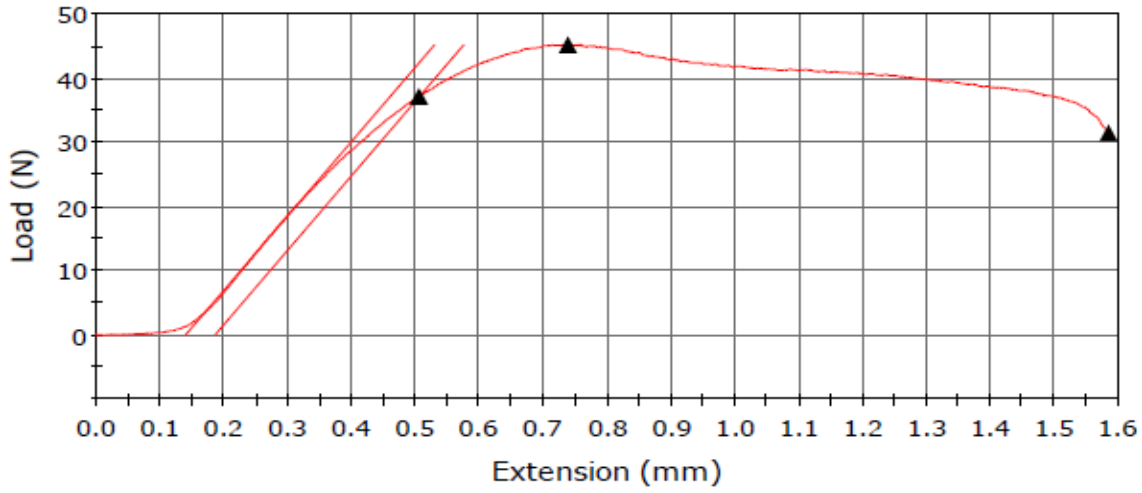


Table 7 Mechanical properties of dry films

Sample name	Tensile strength(M Pa)	Modulus (M Pa)	Length/Width (mm)
S1	24.46	1587	25/5
S2	48.49	1706	25/5
S3	37.99	3202	25/5
S4	60.14	3079	25/5

Complex Modulus of hydrated gels

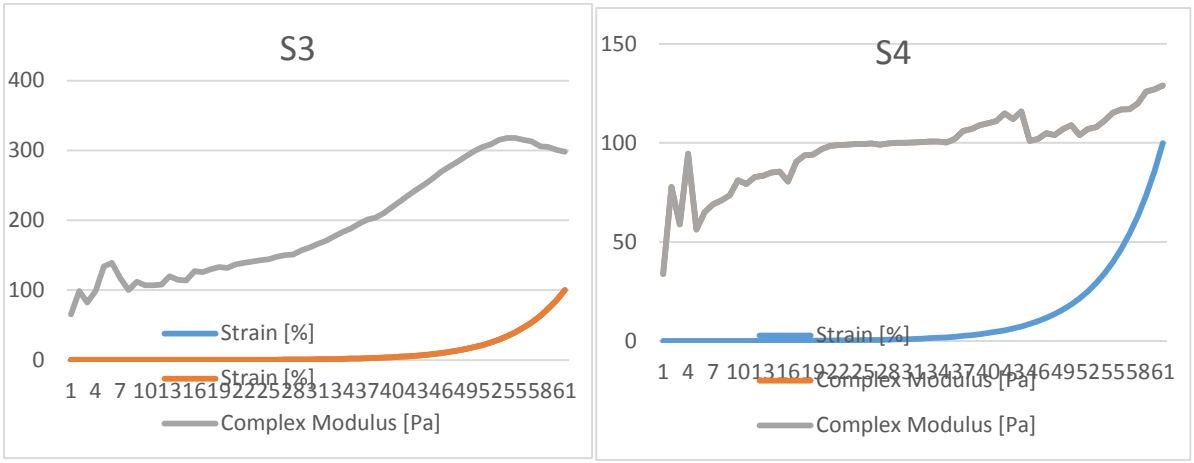
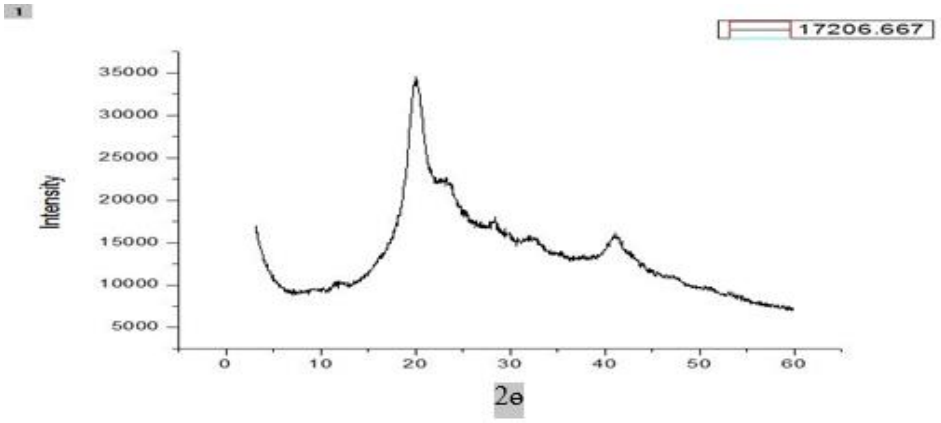


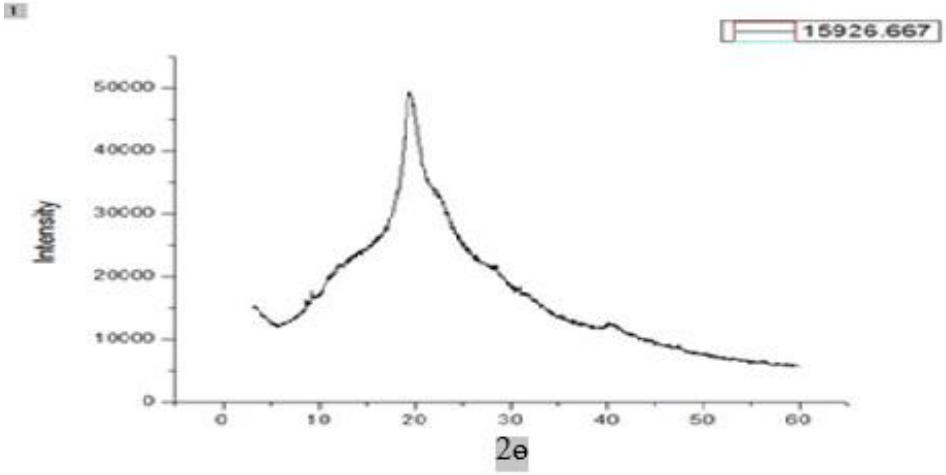
Fig 11 Complex modulus vs Strain %

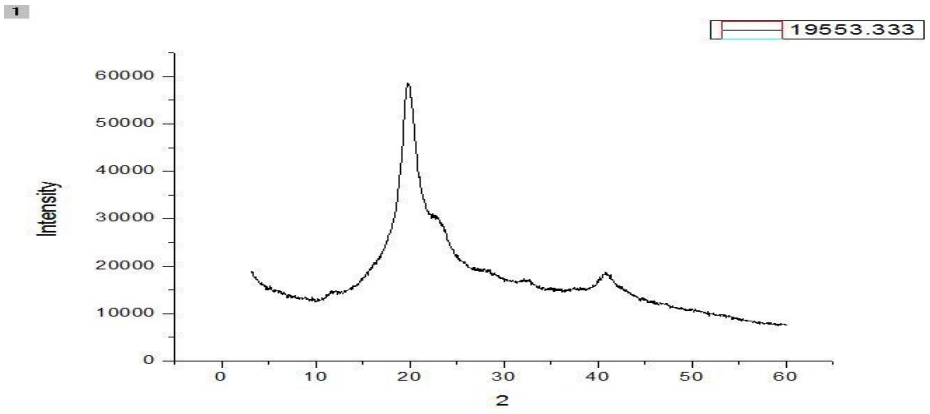
This shows that complex modulus for sample S3, S4 have been comparable with that of crystalline lens. And mechanical strength of the films reduced by adding Gelatin, and sample S 4 have maximum strength of 60.14.We have noticed that after adding Gelatin we were able to decrease mechanical strength from 5000 MPa to around 2000 MPa, cause we don't need that much high modulus for ocular film (Kim, Park et al. 2005).

4.8 XRD ANALYSIS

XRD is our films were performed at room temperature check crystalline sample. Sharp peaks with higher intensities shows crystallinty , if peaks are broad and of less intensity it can said as amorphous XRD was operated at 45 kV and 40 Ma, the diffractometer are measured in 2ɵ of range10-60 at an speed of 10 degree per minute. Basically PVA is shows crystalline nature, it shows peaks 20.On contrary to PVA, PVP shows amorphous, on increase in concentration of PVP peaks become broader and intensity also reduces .This gives the information that on a gelatine and PVP the crystallinity (Pal, Banthia et al. 2007).


17206.667
Intensity
35000
30000
25000
20000
15000
10000
5000
0
10
20
30
40
50
60
2e


15926.667
Intensity
50000
40000
30000
20000
10000
0
0
10
20
30
40
50
60
2e


19553.333
Intensity
60000
50000
40000
30000
20000
10000
0
0
10
20
30
40
50
60
2

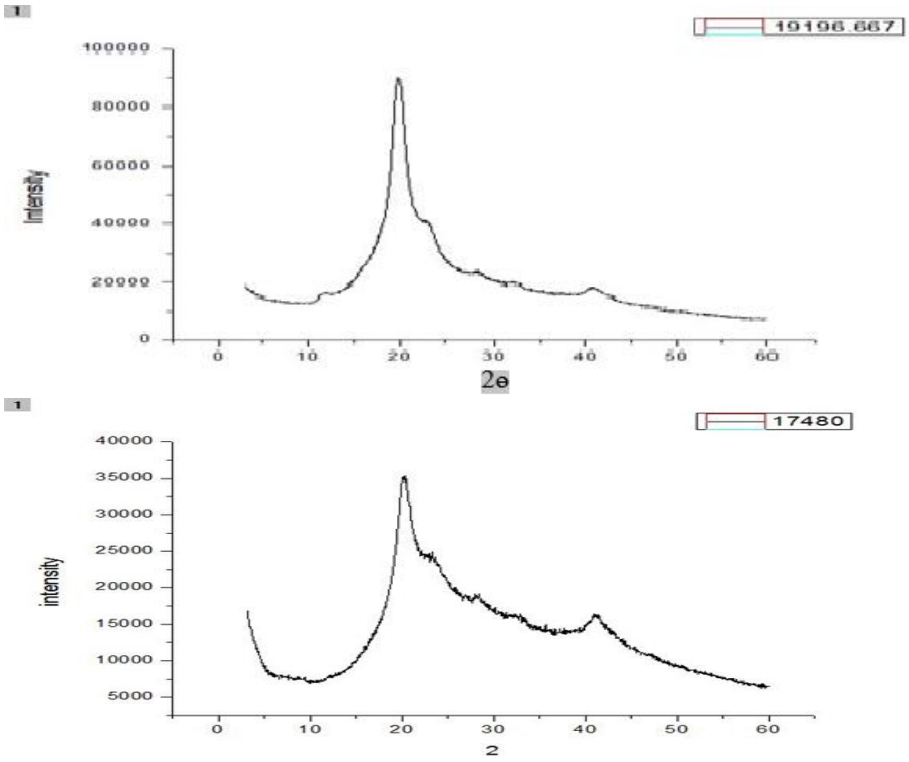


Fig 12 XRD data

As per the XRD data above we can say, peak at 20 due to PVA, its intensity and width increase is due to addition of Gelatin and PVP. Addition of PVP makes films more amorphous. Peaks at 23, 34, and 43(Asma, Meriem et al. 2014) are due to Gelatin.(Liu, Geever et al. 2010)

4.9 HEMOCOMPATIBILITY TEST

This test alludes to capacity of RBCs to break under stress. It's the level of haemolysis that Happens when a specimen of blood sample are kept under osmotic stress. A hyper tonic mixture with 9 % NaCl is utilized to give stress to cells. When cell are placed under a

hypertonic solution because there is a higher concentration of salt outside the cell with respect to inside the cell permits the haemoglobin to remove out of the cell.

By measuring this haemoglobin we can determine percentage haemolysis.

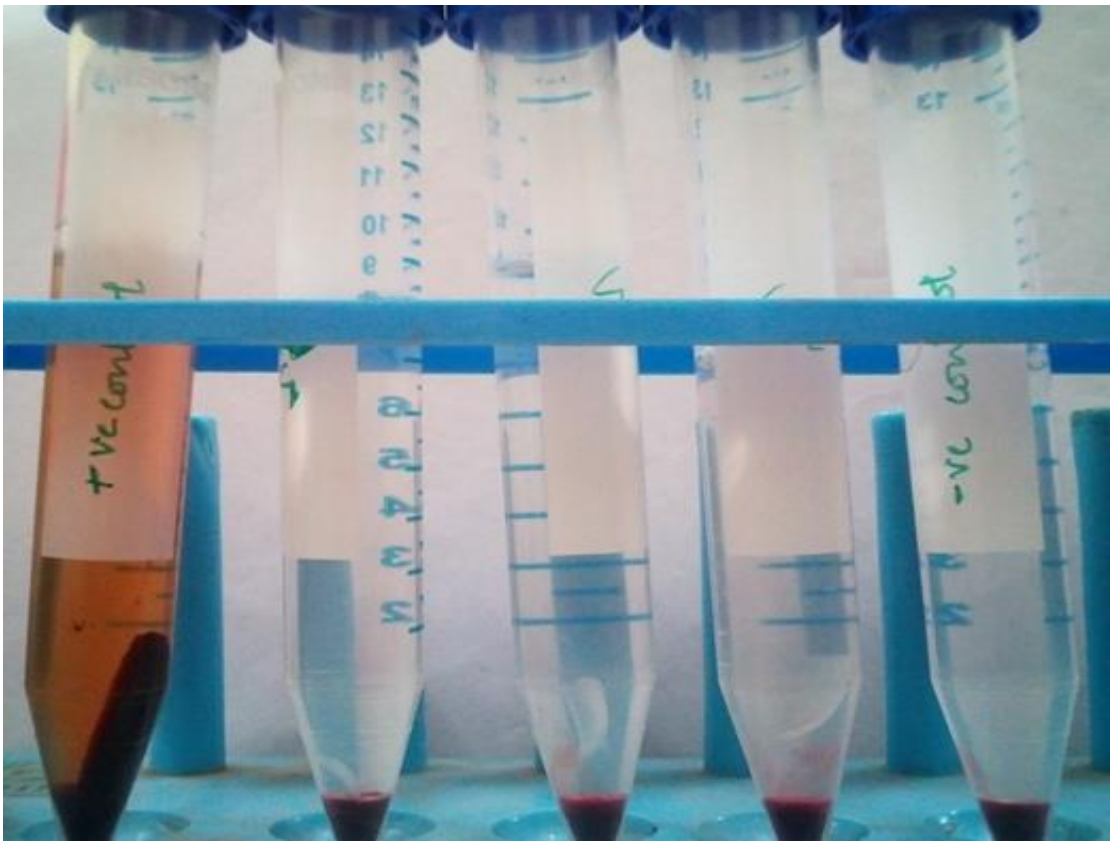


Fig 12 Samples preparation for haemocompatibility

% Haemolysis was calculated using the formula

$$\% \text{ Haemolysis} = (O.D._{sample} - O.D_{-ve\ control}) / (O.D._{+ve} - O.D_{-ve\ control}) \times 100$$

Table 7 %Haemolysis values

Sr, no.	**sample**	**% Hemolysis**
1	+VE control	
2	-VE control	
3	S1	7%
4	S2	4%
5	S3	1%
6	S4	2%
7	S5	5%

As from the readings we can see all readings are below 10% so we can say all are highly haemocompatible. It can be used in body without causing any toxic effect to a person's blood

CHAPTER 5

CONCLUSION

5. CONCLUSION

PVA/PVP Blends are versatile candidate for medical applications and films have been Obtain. We have seen problems using different cross linker like GA causes brittleness to the film, and KOH/Na_2SO_4 causes whiteness in gels, so we can't use them also. So for this only we have used Freeze thawing method. With adding Gelatin a hydrophilic compound we are able to decrease its strength

After freeze thawing samples were prepared by solvent evaporation method. Addition of Glutaraldehyde affected the structure of blend making it more rigid and compact, although difference was slight as physical cross-linking already exists between the two polymers. These films have mechanical strength, swelling and solubility in water. On the basis of all the result it can be concluded that films S3 was found best and as from data increase biocompatibility, transparency, contact angle, complex modulus it can be used PVA can be used as a biomaterial for IOL

REFERENCES

*Asma, C., et al. (2014). "PHYSICOCHEMICAL CHARACTERIZATION OF GELATIN-CMC COMPOSITE EDIBLES FILMS FROM POLYION-COMPLEX HYDROGELS." Journal of the Chilean Chemical Society **59**(1): 2279-2283.*

BALA, J. DEVELOPMENT OF PVA/PVP BASED CRYO-CONTAINERS FOR VITRIFICATION OF BIOLOGICAL SAMPLES, National Institute of Technology Rourkela.

*El-Mohdy, H. A. and S. Ghanem (2009). "Biodegradability, antimicrobial activity and properties of PVA/PVP hydrogels prepared by γ-irradiation." Journal of Polymer Research **16**(1): 1-10.*

Finch, C. A. (1973). Polyvinyl alcohol: properties and applications, Wiley London.

*Geetha, M., et al. (2009). "Ti based biomaterials, the ultimate choice for orthopaedic implants–a review." Progress in Materials Science **54**(3): 397-425.*

*Hench, L. L. (1998). "Biomaterials: a forecast for the future." Biomaterials **19**(16): 1419-1423.*

*Jones, D. W. and A. S. Rizkalla (1996). "Characterization of experimental composite biomaterials." Journal of biomedical materials research **33**(2): 89-100.*

*Kenawy, E.-R., et al. (2010). "Controlled release of atenolol from freeze/thawed poly (vinyl alcohol) hydrogel." Journal of Saudi Chemical Society **14**(2): 237-240.*

*Kim, D.-J., et al. (2005). "Tensile strength of aqueous-based alumina tapes using a PVP–PVA–gelatin cobinder." Ceramics international **31**(4): 577-581.*

*Kobayashi, M., et al. (2005). "A two year in vivo study of polyvinyl alcohol-hydrogel (PVA-H) artificial meniscus." Biomaterials **26**(16): 3243-3248.*

*Leone, G., et al. (2011). "A PVA/PVP hydrogel for human lens substitution: Synthesis, rheological characterization, and in vitro biocompatibility." Journal of Biomedical Materials Research Part B: Applied Biomaterials **97**(2): 278-288.*

*Liu, Y., et al. (2010). "Thermal behavior and mechanical properties of physically crosslinked PVA/Gelatin hydrogels." Journal of the mechanical behavior of biomedical materials **3**(2): 203-209.*

*Mansur, H. S., et al. (2004). "Characterization of poly (vinyl alcohol)/poly (ethylene glycol) hydrogels and PVA-derived hybrids by small-angle X-ray scattering and FTIR spectroscopy." Polymer **45**(21): 7193-7202.*

*Pal, K., et al. (2007). "Preparation and characterization of polyvinyl alcohol-gelatin hydrogel membranes for biomedical applications." Aaps Pharmscitech **8**(1): E142-E146.*

*Paradossi, G., et al. (2003). "Poly (vinyl alcohol) as versatile biomaterial for potential biomedical applications." Journal of Materials Science: Materials in Medicine **14**(8): 687-691.*

Park, J. B. and J. D. Bronzino (2002). Biomaterials: principles and applications, crc press.

Picha, G. J. and D. Thompson (2014). Hard-Tissue Implant, Google Patents.

*Ramakrishna, S., et al. (2001). "Biomedical applications of polymer-composite materials: a review." Composites science and technology **61**(9): 1189-1224.*

*Refojo, M. F. (1975). Materials for use in the eye. Polymers in Medicine and Surgery, Springer**:** 313-331.*

*Sáenz, A., et al. (1999). "Ceramic biomaterials: an introductory overview." Journal of Materials Education **21**(5/6): 267-276.*

*Singh, B. and L. Pal (2011). "Radiation crosslinking polymerization of sterculia polysaccharide–PVA–PVP for making hydrogel wound dressings." International journal of biological macromolecules **48**(3): 501-510.*